Documentation of test results should be prepared in accordance with the above references.

5.4.2.7 Fan Reliability and Maintenance

Operational reliability is an important consideration in selecting fans for nuclear applications. Even when the system is planned for part-time or intermittent operation, continuous operation may be required after the system goes into service. This should be a consideration in the design and procurement process.

Adequate access for maintenance and service is imperative, and fans installed above floor level must have sufficient clear space around and below for personnel to get to them with the aid of ladders and/or scaffolding. Permanently installed ladders and galleries are recommended to ensure ease of access for maintenance and repair.

Procedures should be developed for periodic, preventative maintenance based on the fan manufacturer's recommendations and actual field operational experience. These procedures are critical for the reliability of the fan and its operational readiness in the event of a DBA.

5.4.2.8 Special Duty Considerations

Temperature, Pressure and Humidity

Fans are constant-volume machines whose airflow rate can be impacted by variables such as temperature, pressure, and relative humidity because they affect the pounds of air being moved. It is necessary to identify and specify these variables for both for normal and accident conditions so the fan manufacturer can make proper fan and drive selections. In addition, temperature, pressure, and humidity can affect fan components such as the bearings and bearing lubricant. Therefore, the fan manufacturer must know these properties to make proper material selections for the fan components.

Material Moving

Fans that are required to move material such as dust (e.g., sawdust) or other particulate matter require identification and specification of the properties of the air stream. Particulates can be abrasive, require high transport velocities, or be composed of corrosive, explosive chemicals. These materials can affect the fan wheel, casing, shaft, bearings, bearing lubricant, etc., and the fan manufacturer must know these properties to make the proper material selections for the fan components.

Contaminated Air Moving

Fans that are required to move contaminated air (primarily radioactive particles in nuclear facilities) also need to have these properties identified and specified. Radioactive contaminants can affect some of the materials used in fan construction (primarily bearing lubricants) or in ductwork components that are attached to the fan (flexible connections and gaskets). Another primary concern is contaminated leakage into or out of the fan (see Section 5.2.4.3 for information concerning leakage). The fan manufacturer must know the properties of the contaminated air so that proper material selections and leakage provisions can be provided.

5.5 Air Intakes and Stacks

5.5.1 Locating Intakes and Stacks

The design and location of exhaust stacks and air intakes have an important bearing on system performance. If air intakes are too close to the ground, blowing sand, dust, grass clippings, and other particulate matter may be drawn into the building, plugging the supply-air filters and/or reducing their life. Exhaust fumes from vehicles passing nearby or standing close to the building may also be drawn into the building. Intakes must be sited to protect them from snow, ice, and freezing rain during the winter, and baffles or louvers must be provided to give protection from driving rain and to minimize the effect of wind. Architectural louvers should be designed and tested in accordance with AMCA 500-L[43] for pressure drop and water penetration (see Section 5.3.4 for additional information concerning louvers). Wind pressure can have an appreciable effect on flow rates in a low-head ventilation system and can cause pulsations that may disrupt or reverse differential pressure conditions between the zones of the building.

Average wind direction and weather conditions that are likely to cause stack discharges to areas close to the ground (known as looping and fumigation) must be analyzed when establishing the location of stacks and intakes. This analysis is necessary to ensure that stack effluents cannot be drawn back into the building or into an adjacent building. Intakes should be located upwind of stacks (i.e., based on the prevailing wind for the site). Intakes downwind of shipping docks may be prone to drawing vehicle exhaust fumes into the building. Intakes located close to a roof or in a roof penthouse may have the same problems as those located too close to the ground.

Considerable guidance on the location of intakes and stacks is given in Chapter 16 ("Air Flow Around Buildings") of the *2001 ASHRAE Fundamentals Handbook*.[2] The flow around adjacent structures is complex and is affected not only by a building's dimensions, but also by the topography surrounding a building. **FIGURE 5.18** shows the wind and stack flow patterns for a single rectangular building. Air intakes located within the recirculation zone or contaminated region will re-entrain the effluent. Stacks located as shown in **FIGURE 5.19** will minimize re-entry.

Intakes located on the sides of buildings may also be affected by the pressure (positive or negative) that exists at those points. Ventilation systems should be designed and sized to account for this pressure, especially if a negative pressure is possible for a supply system or a positive pressure may exist for an exhaust system. A static pressure at least equivalent to the surface pressure associated with the design wind velocity for the specific location should be included in system pressure calculations. Pressure controls (described in Section 5.6.3) also should be used to regulate flow fluctuations occurring due to the wind velocity and surface pressure.

In northern climates, intakes should be designed to minimize snow entrainment. Even at low velocity through louvers, snowflakes can enter and clog prefilters if they are located close to the louvers. In addition, hoarfrost can form on operable louvers and prevent their operation. Hoarfrost can also block louver screens. To prevent such potential problems, it may be advisable to heat the areas adjacent to the louvers. If snow is blown or otherwise induced into the ventilation system and no provision is made for settling or dropping out snow or ice particles, the filters can become clogged.

To reduce the potential for this problem, whenever possible intakes should not be located on the windward side of buildings. Consideration should be given to modeling flow around buildings and intake structure designs if snow entrainment is causing operating problems that do not have conventional solutions.

For both stacks and intakes, provision should be made for drainage of water or melted snow that may be induced into the system **TABLE 5.4** depicts examples of stack designs that provide rain protection and drainage.

The following factors should be considered when locating stacks.[61]

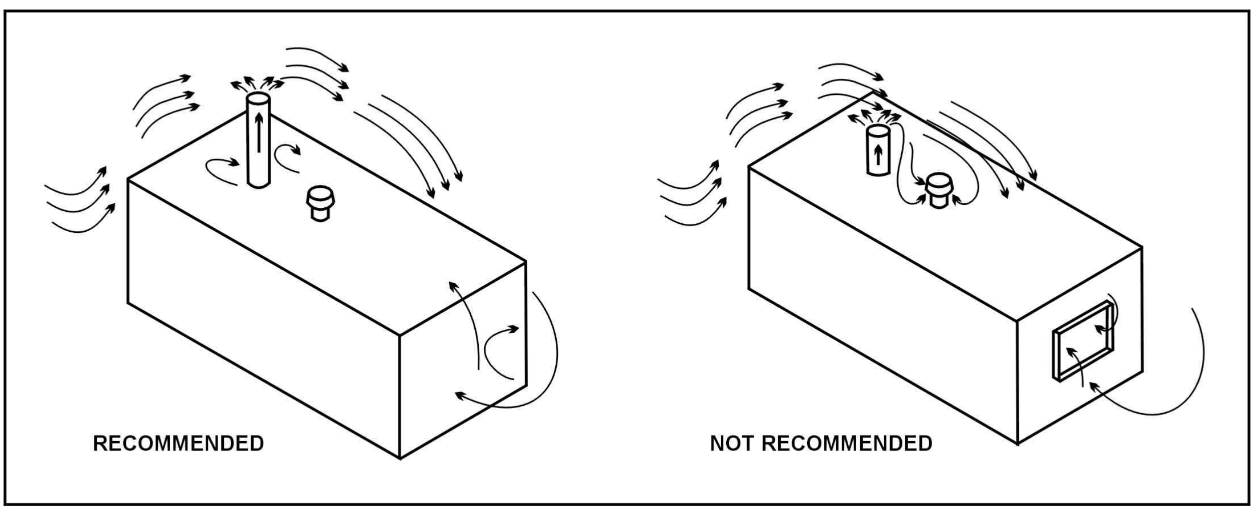

Figure 5.18 – Wind and stack emissions flow patterns

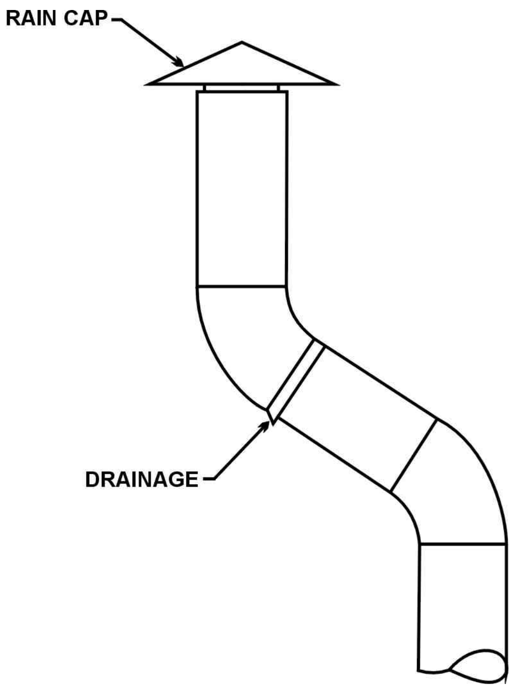

Figure 5.19 – Recommended stack design

- High stack velocity is a poor substitute for proper stack location. A stack velocity to wind velocity ratio of 4:1 is required to discharge effluent out of the recirculation cavity boundary for a stack located flush to a roof.
- If an enclosure is needed around the stack, the stack should extend above the building zone of the enclosure and should not be flush to the enclosure.
- A circular stack shape is recommended. Nozzles may be used at the tip of the stack to increase exit velocity.
- Stack caps that deflect effluent downward are not recommended. High exit velocities will prevent rain from entering. Some drainage provision is recommended instead of rain caps.

5.5.2 Sizing Intakes and Stacks

Air intakes should be sized to minimize pressure drop and maintain air velocity through the free area below the velocity at which water droplets may be entrained (usually less than 500 fpm). Manufacturers should be requested to provide pressure drop and water penetration test results for louvers tested in accordance with AMCA 500-L.[43]

Sizing of stacks is even more important to prevent re-entrainment and ensure proper dispersion. Dispersion calculations should be performed in accordance with USNRC Regulatory Guide 1.72 to determine whether elevated, ground-level or mixed mode effluent release is required to maintain offsite personnel exposures within the plant environmental permit, Plant Technical Specification, and 10 CFR 100 limits. "Elevated release" typically refers to stacks that are situated well above the tallest building. Ground level releases are typically exhaust points located on the building wall or roof. "Mixed mode" refers to stacks that are marginally higher than the tallest building. In each case, location of the stack should be based on the factors discussed in Section 5.5.1.

The exit velocity of the stack should be at least 1.5 times the wind velocity to minimize downwash.[64] Stacks may need to be partitioned or sectioned if multiple systems discharge into the stack and individual system operations do not occur at the same time or frequency. A minimum stack velocity of 2,560 fpm[64] is recommended to keep rain out and prevent condensation from draining down the stack. If condensation may be corrosive, a stack velocity of 1,000 fpm is recommended with a drain at the bottom to remove condensation and a nozzle at the top of the stack to maintain high exit velocity.

Table 5.4 – Instrumentation for nuclear air and gas treatment systems

Filter Train	Humidity	Temp	Press	Diff Press	Level	Notes
Filter Train				I, AH		
▪ Prefilter				I		
▪ Carbon Absorber		AH				5
▪ HEPA Filter				I		
▪ Demister	I					
▪ Heating Coil		I, C				
▪ Cooling Coil		I, C				
Heater		I, C				
Heat Exchanger		I, C				
Pump			I			6
Reaction Chamber		I, C, AH				
Recombiner		I, C, AH				
Evaporative Coolers		I, C				
Air Handling Unit						
▪ Fan						1
▪ Prefilter				I		
▪ Heating Coil		I, C				2, 3
▪ Cooling Coil		I, C				2, 3
Blower/Fan						1
Chemical Addition Tank					I	
Compressor						1
Condenser (steam)			I		I, C, AH, AL	
Refrigeration Equipment						4
Damper/Louver/Valve						7

NOTES:
(1) Equipment operating status should be provided in the control room.
(2) Coil discharge air temperature indicated and controlled.
(3) Units introducing outside air should be provided with freeze protection.
(4) See Appendix RA-II.
(5) 2 stage alarms for high and high-high.
(6) Suction and discharge pressure should be indicated.
(7) Operating status and control should be provided based on system design requirements.

LEGEND:
I = Indication R = Record AH = Alarm High
AL = Alarm Low C = Control

5.5.3 STRUCTURAL DESIGN ASPECTS

Louvers designed for conventional ventilation and air conditioning applications are usually acceptable for use as air intakes for nuclear air cleaning systems. If louvers are required to remain in place following DBEs (such as earthquake or tornado), they should be designed in accordance with the requirements of ASME AG-1, Section DA.[63]

Stacks should be designed in accordance with the requirements of ASME AG-1, Section AA-4000.[63]

Loading due to design wind, tornado, hurricane, and other abnormal meteorological conditions should be included in the structural analysis, as well as dynamic loads due to seismic excitation whenever applicable. Even if not required to remain functional, stacks should be designed so they do not collapse and cause unacceptable damage to surrounding structures, systems, or components. Stiffeners for stacks should be located on the outside to avoid providing ledges for potential "build-up" of radioactive material, even though the air has been "cleaned." The structural design of stacks should be qualified by analysis in accordance with AA-4000. Care should also be exercised in the structural design so that stacks do not "crimp" or bend and cut off the effluent flow if they are subject to a strike by high wind- or tornado-generated missiles.

Openings in nuclear-safety-related structures for either air intakes or exhaust stacks should be protected from the effects of high wind or tornado missiles if such a missile could damage a nuclear-safety-related component and prevent it from functioning. Missile protection typically involves utilizing staggered building wall structures or a lattice of steel bars to prevent a straight-through missile path. Sufficient space must be allocated for these intake structures. Free-area reduction caused by the use of the staggered walls or steel bars in the openings must be considered when sizing the openings, particularly intakes, so that velocity requirements are not exceeded.

5.6 INSTRUMENTATION AND CONTROL

5.6.1 CODES AND STANDARDS REQUIREMENTS

Instrumentation and control systems, components, and equipment should meet the requirements of ASME AG-1, Section IA.[63] In addition, they should be qualified according to the requirements of IEEE 336,[79] 383,[80] and 384.[81]

5.6.2 FUNCTIONAL REQUIREMENTS

The function of the instrumentation and control systems associated with nuclear ventilation and nuclear air cleaning systems is to control the environment of the space served within the limits of the controlled variable, and to monitor the performance of the system and its components to ensure safe, efficient, reliable operation.

The design of instrumentation and control systems should consider the consequences of single failure[66] as well as environmental conditions.

The primary variables by which nuclear air cleaning systems are controlled are temperature, airflow rate, and pressure. Temperature, pressure, flow, and radioactivity levels are monitored to indicate system performance and alarm abnormal conditions.

Effluent air cleaning systems typically are controlled to maintain a minimum negative pressure or building pressure around a preselected flow rate. Habitability systems are usually controlled to maintain a constant airflow rate that is selected to maintain a positive pressure in the space served. Temperature is also usually controlled for habitability systems.

Instrumentation should be provided to monitor the radioactivity levels of effluent discharged into the atmosphere. Each discharge point that could potentially have concentrations exceeding Plant Technical Specification limits should be monitored. Airflow rates and concentrations of radioiodine, particulates, and noble gases are also required. Values in excess of established high limits should be alarmed in the control room. In addition, airflow rates and radioactivity levels for habitability systems should be monitored and alarmed.

The best indicator of system performance for continually operating systems is the radioactivity levels. Monitoring flow rates and concentrations both before and after air cleaning units could indicate trends in filter degradation. The controls recommended in ASME AG-1, Section IA, Appendix IA-C,[63] (should be provided to assist the operators in monitoring system performance).

5.6.3 AIRFLOW CONTROL

Airflow control is one of the most important control variables for nuclear air cleaning systems. Nuclear air cleaning system pressure could vary by as much as 25 to 30 percent, depending on system components, clean filter pressure drop, and the change-out pressure drop as shown in **TABLE 5.5.** It is recommended (and required by USNRC Regulatory Guides 1.52[7] and 1.140[8]) that airflow rates be maintained within $\pm$10 percent of design to prevent reduction in filter efficiency. The airflow rate is usually required to be automatically controlled by either (1) discharge or inlet control dampers, (2) variable inlet vanes, or (3) variable speed control.